

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of)	
)	
FACILITATING OPPORTUNITIES FOR)	
FLEXIBLE, EFFICIENT, AND RELIABLE)	ET Docket No. 03-108
SPECTRUM USE EMPLOYING)	
COGNITIVE RADIO TECHNOLOGIES)	

To: The Commission

**COMMENTS OF ARRL, THE NATIONAL ASSOCIATION
FOR AMATEUR RADIO**

ARRL, the National Association for Amateur Radio, also known as the American Radio Relay League, Incorporated (ARRL), by counsel, hereby respectfully submits its comments in response to the *Notice of Proposed Rule Making and Order* (the Notice), FCC 03-108, 69 Fed. Reg. 7397 *et seq.*, released December 30, 2003. The Notice was published in the Federal Register on February 17, 2004, and therefore these comments are timely filed. The Notice seeks comment from the public on various issues related to Cognitive Radio Technologies (CRTs), and makes proposals for improving spectrum efficiency by enabling more effective use of cognitive radio technologies. While ARRL is supportive of the concept of CRTs, and though Amateur Radio operators are currently experimenting with CRTs, it is urged that the Commission avoid any large scale deployment of CRT technology, especially with respect to unlicensed devices in spectrum now used regularly by licensed radio services, until further experience with the technology is obtained. ARRL states as follows:

I. Introduction

1. The Notice defines a cognitive radio (CR) as “a radio that can change its transmitter parameters based on interaction with the environment in which it operates.” The Notice continues: “This interaction may involve active negotiation or communications with other spectrum users and/or passive sensing and decision making within the radio.¹ The majority of cognitive radios will probably be SDRs,² but neither having software nor being field reprogrammable are requirements of a cognitive radio.” (Notice, at ¶10) The Notice cites the example of a cordless telephone that operates in the 43.71-44.49 MHz band as a simple form of a cognitive radio without modifiable software.

2. The Commission’s Notice first discusses potential cognitive radio capabilities. It then asks a series of questions concerning how cognitive radio technology can be used to facilitate improved use of the spectrum. The Notice specifies in detail the technical capabilities that are or could be incorporated into cognitive radio systems. The Commission seeks comment on how FCC rules should be modified, if at all, “to enable a

¹ At the outset, this proceeding illustrates a substantial philosophical change in the means by which interference is regulated. The Communications Act instructs that interference is to be managed by issuing licenses only to qualified entities and holding the licensees responsible for interference avoidance and mitigation. The Commission, especially in this instance, prefers to eschew licensing in favor of building interference avoidance into the equipment. The principal disadvantage of the Communications Act approach is that there is no good way to ensure that only licensees have access to transmitting equipment. The principal disadvantage of the Commission’s approach in this proceeding is that it combines imperfect interference avoidance with limited flexibility.

² ARRL’s understanding of software-defined radios (SDRs) is that they are, in essence, digital computers connected to an antenna, controlled by software. Presently, most software receivers have an analog front end consisting of band-pass filtering, a low-noise RF amplifier to set a low system noise level, and a local oscillator and mixer to heterodyne the signal to an intermediate frequency where analog-to-digital (A/D) conversion, digital filtering and demodulation takes place. Recently, however, there have been some software receivers that perform A/D conversion immediately after the antenna.

more effective use of cognitive radio technologies, including potential applications across a variety of scenarios involving both licensed spectrum and unlicensed devices” (Notice, at ¶7).

3. ARRL is very much concerned about the proposals in the Notice concerning unlicensed devices. Among other things, the Notice proposes to permit up to a six-fold (8 dB) increase in the power level of a Part 15 device operating in the 902-928 MHz, 2400-2483.5 MHz, 5725-5825 MHz, or 24 GHz bands, if the devices are located and operate in a “rural area”. If adopted, this would raise the permissible transmitter power output of such devices from one watt (30 dBm) to 6 watts (37.8 dBm) and the allowable EIRP from 4 watts (36 dBm) to 24 watts (43.8 dBm). The Notice discusses several possible configurations which could determine how such a device would decide if whether or not it is situated in a rural area. This proposal is ill-advised for numerous reasons, as will be discussed below.

II. SDRs and Cognitive Radios in the Amateur Service

4. Early in the last decade, digital signal processing (DSP) techniques became practical and cost-effective in manufactured amateur transceivers. At that time, it was virtually impossible for users to alter functionality by changing embedded software, although some transceivers met certain criteria we now use to define what is an SDR. Beginning in 1997 with the Kachina 505DSP, amateurs were able to upgrade units by buying and installing factory-programmed ROM cards. Ten-Tec and other commercial manufacturers of Amateur Radio equipment followed with units that could be upgraded by downloading software into FLASH ROM from a personal computer (PC). Again, this working software was only available from the manufacturer.

5. Amateur experimenters were quick to appreciate the great flexibility and potential of software controlled or defined equipment and they experimented with their own algorithms on their equipment. Many espoused development of open hardware and software designs that would enable them to advance Amateur Radio's time-honored traditions of innovation. ARRL recognizes SDR and CRTs as an excellent opportunity to advance CR technology in our service. We have seen an ever-increasing number of programmers, students and communicators drawn to SDR by the possibilities.

6. From the perspective of the Amateur Service, most recent efforts of individual amateurs have been focused on use of DSP boards to perform digital filtering and demodulation. Manufacturers of amateur equipment have included DSP features in transceivers, with vast improvement in receiver performance, especially in high-frequency bands, in high ambient noise areas. There is substantial work ongoing by amateurs in their development of DSP which is generated by use of sound cards. European and American amateur experimenters have cooperated in this developmental work. Now, platforms that support independent software development are a practical reality. There are open designs with sufficient supporting documentation. It has been a useful and exciting learning experience for all involved, including students using Amateur Radio in course curricula, which has stimulated the exchange of ideas and information among amateurs, professionals and academics. ARRL supports efforts by the Commission to continue this trend in amateur experimentation using CRTs. The Amateur Service, because of its present variety of shared allocations, is the proper environment in which to develop, test and implement new applications of cognitive radio technologies. The ARRL, through its technical publication *QEX* (focused primarily on

Amateur Radio experimentation), has given and continues to give high profile to new technologies available to the Amateur Service, such as SDRs and CRTs.

III. Spectrum Allocation Issues

7. ARRL is satisfied that the existing service rules set forth in Part 97 are adequate to properly regulate Amateur spectrum use as cognitive radio technologies mature. ARRL has certain proposals which will shortly be filed with the Wireless Telecommunications Bureau for service rule changes in the Amateur Service that will generally encourage greater experimentation and facilitate conversion to digital technologies, which are critical to CRT development. These include regulation of emissions by bandwidth, rather than by emission type (the current regulatory scheme) which stifles digital experimentation. ARRL envisions that, in the future, CRT technologies will, within the allocations of each radio service, provide significant improvements in spectrum efficiency. In the Amateur Service, which is essentially an experimental service, and one that is obligated to provide emergency and public service communications where and when needed, there are no allocation changes that are necessitated or occasioned by cognitive radio technologies at present.

IV. Enforcement Issues

8. At paragraph 94 of the Notice, the Commission asks for advice on enforcement of existing rules and those proposed in the Notice. ARRL has been satisfied for the past five years with the level of enforcement of existing Part 97 rules. The good work of the Special Counsel for Amateur Radio Enforcement, together with the help of volunteers

authorized by the Communications Act of 1934 to assist the Commission in compliance efforts in the Amateur Service, have created an environment of rule compliance which is positive and encouraging. The Enforcement Bureau has done a good job in recent years and there are no serious compliance problems in the Amateur Service now. This level of enforcement is adequate for the foreseeable future to ensure compliance in the Amateur Service, whether or not new rules for CRTs are adopted. There is no need for separate rules regarding Cognitive and Software Defined Radios. They should and can be regulated within the existing rules.

9. The Commission expressed concern in the SDR proceeding, Docket 00-47, about the ability of SDR amateur equipment to be misused.³ The concern seems to stem from the capacity of SDRs and CRTs to be programmed or configured to operate on frequencies other than those within Amateur Service allocations. The same concern is expressed at Paragraph 90 of the Notice in this proceeding. The Commission discusses equipment that is not subject to Equipment Authorization (certification), and expresses

³ There are in fact three separate concerns. The first is that Amateur Radio operators will operate their equipment outside allocated amateur bands. As discussed herein, that has not been a regulatory problem to any significant extent at all over periods of many years, notwithstanding the ready availability of commercially manufactured Amateur equipment which is capable of transmission on all frequencies between 3 and 30 MHz, for example. The other concern, which is of only slightly greater magnitude, is that non-amateurs will have ready availability of Amateur equipment for operation on Amateur or other allocations. This is something of a problem now, but there is nothing inherent in SDR or CRT technology which would exacerbate the problem. That is, rather, a larger problem of the absence of point-of-sale control of Amateur Radio transmitting equipment. The third concern is of greater significance: some unscrupulous manufacturers do make equipment which would never be used as a practical matter by Amateur Radio operators, but which is, nevertheless, marketed as “Amateur Radio equipment”, generally in publications and sources which are not targeted to, or typically read or viewed by, licensed Amateur Radio operators. These manufacturers seek to avoid equipment authorization requirements, and simply label their equipment “Amateur Radio equipment.” Again, this is not a problem which would be made any worse than it already is by the adoption of rules to implement SDR or CRT technology. A broad solution to the third problem is being discussed now between ARRL and Commission Enforcement Bureau staff, looking toward a better, more appropriate regulatory definition of Amateur Radio equipment. Such a definition would separate legitimate, manufactured equipment genuinely used and useful in the Amateur Service from that aimed principally at, for example, Citizen’s band or “freeband” pirate radio operators.

concern about SDRs being operated outside allocated bands. The Notice proposes to adopt rules requiring that “manufactured” SDRs used in Amateur Service allocations must, “in hardware”, restrict their transmit ranges to amateur bands only. The proposed rule would not affect other types of personally constructed Amateur equipment or non-SDR, manufactured Amateur equipment.

10. ARRL is sympathetic to the Commission’s concern, and appreciates the Commission’s sensitivity to the need to encourage, rather than discourage, Amateur experimentation and innovation. (Notice, at ¶90). However, the Commission’s concern about out-of band operation of Amateur equipment is, in ARRL’s view, overstated. The Amateur Radio Service has a long history that has clearly demonstrated the dedication of its licensees to a self-regulated and disciplined Service. This is especially true with regard to transmitter frequency restrictions. For decades, amateurs have advanced radiocommunication technologies by designing, building and experimenting with radio. Whatever the type of radio built or operated, it has always been the licensee’s responsibility to ensure that the radiated emissions are within the law. Hardware restrictions have not been imposed in the Amateur Radio Service, and the instant proposal creates a precedent that will inhibit experimentation and refinement of hardware. Though transmitter frequency control may now be accomplished by either hardware or *software*, as is the case with SDRs, there is no practical difference in the responsibility of any Amateur Station licensee to operate in accordance with established FCC regulations. ARRL requests that no additional regulations be applied to the Amateur Radio Service under Part 97 with respect to SDRs and CRTs. There are other, less intrusive means of insuring that legitimate Amateur Radio equipment is not misused

by licensees or non-licensees, and there is a more efficient means of insuring that unscrupulous manufacturers do not market products labeled as Amateur Radio equipment which in fact has little, if any, utility to a law-abiding Amateur Radio licensee.

11. Amateur equipment since the 1940s has been designed such that it is capable of transmitting on certain bands other than amateur allocations. Well-known, legitimate uses of this capability include the thousands of volunteers who utilize Amateur equipment and provide communications in support of important organizations such as the Military Affiliate Radio System (MARS) and the Civil Air Patrol (CAP). Neither of these services requires certificated transmitting equipment. Furthermore, within the Amateur Service there are legions of transmitters, both new and old, that may be easily modified to enable general-coverage-transmit. Restrictions on the transmission capability of Amateur SDR or CRT equipment will add cost to equipment, but no significant enforcement benefit. Neither does Certification, per se, have any bearing on the potential for its misuse. Certificated, general-coverage transmitting equipment for radio services other than the Amateur Service, made by reputable manufacturers (including equipment that is readily modifiable to operate on other than Amateur bands) is readily available without restriction worldwide. Such authorized equipment is not banned from use in the Amateur Radio Service. The flexibility in the design and deployment of equipment used by licensed radio amateurs is intentional and necessary in order for our Service to thrive.

12. Some Amateur SDR equipment uses personal computers (PCs) for most of the modulation processing and for control of output frequency. Such SDR designs are not typically equipped with microprocessors. To limit transmit frequency range in hardware alone, as proposed, would be a practical impossibility. Another practical

example of the difficulty with frequency restrictions in Amateur equipment is the adaptation of use of such equipment for microwave communications. Amateurs typically use broadband exciters in conjunction with transverters to generate signals in microwave bands. The exciters often cover wider frequency ranges than a single Amateur band. Restriction of the frequency range of such equipment would make microwave operation difficult and significantly more expensive for radio amateurs. ARRL is confident that there is no need for new rules to control transmit frequencies of SDRs. Existing Part 97 rules regarding specific illegal transmissions and equipment authorization requirements in other radio services are jointly sufficient from a regulatory perspective to preclude misuse of cognitive radios. ARRL does understand, of course, the need for transmitter frequency restrictions dealing with unintended out-of-allocated-band emissions. However, SDR and CRT technology poses no new or additional threat of out-of-band emissions, and Part 97 now adequately addresses this issue. In fact, SDR and CRT technologies greatly assist in the shaping of the emission masks and contribute to the prevention of spurious, harmonic and other unintended out-of-band emissions.

V. Unlicensed Devices

13. The Notice, at paragraphs 38 and 39, states as follows:

We propose to allow a transmitter power increase of up to 6 times (approximately 8 dB) higher than the current limits in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands under Section 15.247 of the rules, and in the 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24.0-24.25 GHz bands under Section 15.249 of the rules (footnote omitted). This increase is consistent with the Commission's recent proposal in ET Docket 03-201 to permit a power increase of 8 dB for spread spectrum systems using sectorized antennas (footnote omitted). This proposal would increase the signal range by a factor of up to 2.5 and increase the coverage area by a factor of six as compared to the current limits, which would be particularly beneficial for wireless LAN and WISP uses (footnote omitted). Specifically, the proposed maximum transmitter power levels or maximum field strength levels in areas with limited spectrum use would be:

a. Spread Spectrum Devices (§ 15.247):

6 watts for digital transmission systems and the following frequency hopping systems: systems in the 2400-2483.5 MHz band using at least 75 hopping channels, all systems in the 5725-5850 MHz band and systems in the 902-928 MHz band using at least 50 hopping channels

1.5 watts for frequency hopping systems in the 902-928 MHz band using at least 25, but fewer than 50 hopping channels

0.75 watts for frequency hopping systems in the 2400-2483.5 MHz band using fewer than 75 hopping channels

Unlicensed operation in the 900 MHz, 2.4 GHz, 5.8 GHz and 24 GHz bands (§ 15.249)

125 millivolts per meter at a distance of 3 meters in the 902-928 MHz, 2400-2483.5 MHz and 5725-5875 MHz bands

625 millivolts per meter at a distance of 3 meters in the 24.0-24.25 GHz band.

We note that all of the bands where higher power operation is proposed are allocated on a primary basis for ISM equipment, which is generally not susceptible to interference from other devices (footnote omitted). However, each of these bands is also used by licensed services that are entitled to protection from interference by Part 15 devices. For example, the 902-928 MHz band is used by the Location and Monitoring Service (LMS) (footnote omitted), and all of these bands are used by Amateur Radio licensees. Because we are proposing to both limit higher power operation to areas with limited spectrum use and require devices to sense spectrum use before commencing transmissions, we believe that implementation of this proposal would not significantly increase the interference potential to licensed services that operate in one or more of the subject ISM bands. We seek comment on this view. We also seek comment on whether any particular licensed uses of these bands or portions thereof should receive greater protection or be excluded from this proposal? For example, the 2400-2402 MHz band is used by the Amateur Satellite Service, which we have noted is potentially more vulnerable to aggregate interference than other applications (footnote omitted).

14. The bands mentioned specifically in the Notice are Amateur allocations which have been made available for Part 15 use on a non-interference basis. These bands have, over time, been rendered less useful for Amateur operation than heretofore, due to the increasing noise floor and aggregate interference levels from increasing numbers of Part 15 devices, and because the fundamental concept of unlicensed operation has been corrupted by the proliferation of such devices and the obvious impracticality of enforcement of the Part 15 rules. The use of such Amateur bands for new Part 15 devices incorporating cognitive radio technologies using *existing Part 15 power and spectral*

density levels is not cause for any additional concern. However, ARRL is very much concerned about any use of Amateur allocations, whether or not presently available for Part 15 devices, at the power levels or power spectral densities proposed in the Notice.

15. As ARRL has argued to the Commission repeatedly, Section 301 of the Communications Act of 1934 precludes the deployment and operation of high-power, unlicensed Part 15 devices, whether or not incorporating SDR or CRT capabilities.

Section 301 of the Communications Act of 1934 states, in relevant part, that:

No person shall use or operate *any apparatus* for the transmission of energy or communications or signals by radio...except in accordance with this Act *and with a license* in that behalf granted under the provisions of the Act.⁴

By enacting Section 301, Congress prohibited wireless transmissions without a license.

The only (very limited) exceptions to this are set forth in Section 307 of the Communications Act of 1934, as amended, and none of those pertain to unlicensed devices generally. The licensing requirement limited the number of occupants of the spectrum and therefore limited interference. The entire purpose of Section 301 was the avoidance of interference.⁵ The rules for unlicensed devices originated in 1938.⁶

According to the Commission, the rules were based upon the rationale that:

If radiation can be kept within certain fixed limitations, a general assumption can be made that such operations will normally not cause interference to interstate communications or otherwise have interstate effects bringing such operations within the purview of those which must be licensed under Section 301 of the Communications Act.⁷

⁴ 47 U.S.C. § 301 (emphasis added).

⁵ See, Paglin, Max D., A Legislative History of the Communications Act of 1934, at 62-72 (1989).

⁶ See, Revision of Part 15 Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, General Docket 87-389, First Report and Order, 4 FCC Rcd. 3943 (1989).

⁷ *Amendment of Part 15 of the Commission's Rules Governing Restricted Radiation Devices*, Docket No. 9288, *First Report and Order*, 13 RR 1543, 1544 (1955).

Therefore, the adoption of the Part 15 concept was premised on the false assumption that Section 301 only applied to interstate transmissions and that low power devices could be permitted on an unlicensed basis because such transmissions generally lacked an interstate component. That concept was in error, inasmuch as it was always intended by Congress that Section 301 apply to intrastate as well as interstate transmissions. The case law was consistent on that subject,⁸ and in 1982, Congress clarified once and for all that the Commission's jurisdiction over radio communications extends to intrastate as well as interstate communications.⁹ Therefore, by 1982, the flawed rationale for the operation of unlicensed devices was out the window. ARRL has urged that the Section 301 licensing requirement is, on its face absolute,¹⁰ and that unlicensed devices can be authorized only if it can be found that the operating parameters proposed for a given Part 15 device are such that the devices, individually and in the aggregate, will have no substantial interference potential to licensed radio services. The Commission has in recent years butchered the concept and violated the Communications Act, and would again by the proposal in this proceeding to license extremely high power Part 15 devices.

16. The proposed rules would allow Part 15 devices in "rural markets" to operate using cognitive interference "avoidance" techniques to use power levels up to 6 times (8

⁸ See, e.g. *Fisher's Blend Station, Inc. v. Tax Commission of Washington State*, 297 U.S. 650, 655 (1936).

⁹ See, Communications Amendments Act of 1982, Pub. L. 97-259; H.R. Conf. Rep. No 97-765 at 31-32 (1982); reprinted at 1982 U.S.C.C.A.N. 2261, 2275-76.

¹⁰ The Commission has in the past suggested that Section 302(a) of the Communications Act of 1934 creates independent statutory jurisdiction to permit whatever unlicensed device configuration it wishes to authorize. That is plainly wrong. Congress adopted Section 302(a) in 1968 to extend the Commission's authority over the manufacturers of equipment. While Section 301 is aimed at the operation of equipment, Section 302(a) is a proactive regulatory mechanism requiring mitigation of interference before equipment reaches the marketplace. The express intention of Congress was to eliminate the *post hoc* approach to controlling interference.

dB) higher than what the present rules would allow, in bands from 902 MHz through 24.25 GHz. However, there is no plan or regulatory technique which can successfully limit the deployment of these devices to “rural areas.” Nor does the “rural area” concept contribute to interference avoidance where Amateur Radio operation, which occurs frequently in rural areas, and where extremely weak received signals over long propagation paths are utilized as the rule rather than the exception. Neither is there apparently a safe means of deployment of high-power unlicensed devices and systems, which would be operated by non-technical individuals who are not skilled in managing the environmental effects of RF energy.

17. At current Part 15 power limits, the limiting factor for the range of Part 15 devices is the radio horizon, not the power. It is clear that it would be Amateur receivers, not the higher power transmitters, which would be adversely affected by interference from high-power Part 15 devices. It is difficult or impossible to ascertain when a given receiver is being operated, whether or not in a “rural area” and therefore whether or not the Part 15 device, when it operates, would interfere with Amateur Radio communications. Amateur transmissions might be detected by high power Part 15 CRTs, but Amateur communications would suffer significant interference, because cognitive radio technology could only sense the presence of transmitted signals, not receiver operation.

18. At present, Part 15 transmitted power levels are based on operation of one single device, which acts as a point-source radiator. As the Notice clearly indicated, the effects of aggregate interference, or aggregate noise levels, which may have significant impact on Amateur or Amateur-Satellite operations (especially in the 2400-2402 MHz

band) are virtually unknown.¹¹ Additionally, there is at present no regulatory concept of distributive systems with regard to the proposed higher power levels. The permitted transmitter power levels for Part 15 devices in the United States are already set extremely high as compared to power limits established for unlicensed devices in virtually all other developed countries. The Commission proposes in this instance to dramatically increase power levels for Part 15 devices without any technical underpinning at all. Where are the studies of aggregate interference and noise levels? Where are the results of the ambient noise studies supposedly being developed by the Technological Advisory Council? Why is the Commission content to make proposals that have profound, and obviously irreversible interference effects without the slightest real-world test deployment of the unlicensed systems to be authorized? A 6-watt TPO transmitter with a 24-watt EIRP cannot under any definition be considered either a “low power” or “Part 15” device. Even if the vague and subjective concept of “rural area” operation could be incorporated successfully in a CRT device, and even if Amateur communications could somehow be protected by limiting the operation of such high-power Part 15 devices to transmit only in a “rural area” (neither of which is possible), the range and interference contours of such transmissions would clearly extend far beyond the boundaries of whatever the configuration of the device would deem a “rural area”.

19. Section 44 of the Notice states:

As discussed above, we propose that unlicensed devices be permitted to operate at higher power in areas with limited spectrum use. We propose that limited spectrum use be defined as the authorized band of operation, *e.g.*, the 2400-2483.5 MHz band, having a certain percentage of spectrum unused. We propose

¹¹ The Amateur Service has a domestic primary allocation at 2400-2417 MHz, and the Amateur Satellite Service is primary at 2400-2402 MHz.

to define “unused spectrum” for this purpose as spectrum with a measured aggregate noise plus interference power no greater than 30 dB above the calculated thermal noise floor within a measurement bandwidth of 1.25 MHz, which is the same value specified for unlicensed PCS devices (footnote omitted). We also propose that a device must be able to sense across the entire authorized band of operation to determine spectrum occupancy before commencing transmissions at higher power. We seek comment on these proposals, including the specific percentage of spectrum that must be vacant for a band to be considered “empty enough” to allow higher power transmission. We seek comment on the specific 30 dB monitoring threshold level proposed in these bands (footnote omitted). Because some devices that operate in the spread spectrum bands hop frequency and may not be on a particular frequency at a given instance in time, we seek comment on how long a device must sense a band of spectrum to determine it is unused before the device can transmit at higher power. We also seek comment on the type of receive antenna that should be used in measuring spectrum occupancy, whether the proposed monitoring threshold is reasonable and how wide a frequency band should be monitored to make this determination. We further seek comment on the capabilities a device needs to determine when spectrum is empty enough, whether the required capabilities are achievable now or in the near future, and whether they could be economically incorporated into devices.

ARRL is concerned with the proposal “...that a device must be able to sense across the entire authorized band of operation to determine spectrum occupancy before commencing transmissions at higher power...including the specific percentage of spectrum that must be vacant for a band to be considered “empty enough” to allow higher power transmission.” The Amateur Service has numerous operations involving “weak signals” that approach a 0 dB signal to noise ratio. Typical amateur “weak signal” operations involve a significant amount of monitoring over long periods without transmitting. For example, it is not unusual for amateurs operating Earth-Moon-Earth (EME, or “moonbounce”) or conducting terrestrial propagation experimentations, in both suburban and rural areas to monitor for extremely weak signals for periods of time exceeding an hour. Amateurs will frequently wait long periods of time for propagation paths to open. A frequency or series of frequencies that are being monitored by an amateur are not “unused” and is therefore not to be considered a “white space” or “empty enough” in the

spectrum by a cognitive radio. In this same regard, the Commission should also take into consideration services, such as the earth exploration-satellite service – passive (EESS-passive) and radio astronomy (RA), whose operations are receive only, and as such, their allocated bands should not be available for Part 15 cognitive radio transmissions.

V. Digital to Analog Conversion

20. The Notice, as discussed above, described concerns about amateur equipment, specifically with regard to transmitter frequency control in section 90 of the Notice.

The Notice also requests comment on high-speed digital-to-analog converters (DACs) (§§ 91-92). The issue is whether general-purpose, high-speed DACs might easily be adapted to make illegal transmitters when coupled to external power amplifiers. In sections 91 and 92, the Notice states:

At present there is a clear distinction between radio transmitter technology, regulated under Section 2.801(a) of our rules and various radio service rules, and personal computer technology, regulated in a much less restrictive way under Subpart B of Part 15 of our rules. However, increasing computer speeds and speeds of digital-to-analog converters (DAC) (footnote omitted) may well blur this distinction. A general purpose computer capable of outputting digital samples at rates in the million sample/seconds range or higher could be connected to a general purpose high-power, high-speed DAC card which could effectively function as a radio transmitter. The marketing of such computers, DACs, and software to make them interact could undermine our present equipment authorization program at the risk of increasing interference to legitimate spectrum users since none of them would be subject to the normal authorization requirements. At present this is not a problem, but we wish to consider modest steps now to help ensure that this scenario does not become a serious problem.

While such high-speed DACs are presently marketed to the scientific community at high unit costs, we are not aware of any which are marketed as consumer items. We seek comment on whether we need to restrict the mass marketing of high-speed DACs that could be diverted for use as radio transmitters and whether we can do so without adversely affecting other uses of such computer peripherals or the marketing of computer peripherals that cannot be misused. We seek comment on one possible approach as well as welcoming alternative proposals. Would it make sense to require that digital-to-analog converters marketed as computer peripherals that 1) operate at more than one million digital input samples/second, 2) have output power levels greater than 100 mW and, 3) have an output connector for the analog output be limited in marketing to commercial,

industrial and business users as we require for Class A digital devices? Would it be preferable to characterize such systems in terms of output frequency and bandwidth rather than input sampling rate? What sampling rate and power limits would be needed to avoid impacting DACs that might have a legitimate consumer use such as, for video systems and other media applications? Is there a practical way to incorporate security features that would limit the frequency range or other operating parameters of these devices? We also seek comment on the specific types of devices that would be affected and the potential burden on manufacturers.

16. Current Part 2 and Part 97 rules prohibit the use of any external amplifiers capable of the gain necessary to pose any serious interference threat – when coupled with 100-mW exciters.¹² Restrictions on DAC technology would hinder amateur experimentation with local oscillators, test equipment and other legitimate uses. ARRL believes that such interference, should it ever occur, would best be addressed within existing FCC regulations as an enforcement issue and that further regulation is unnecessary. Therefore, it is recommended that no restrictions on DAC technology be implemented by the Commission with respect to the Amateur Service.

VI. Certification and Testing Requirements for Cognitive Radios

21. Equipment authorization issues relative to cognitive radio technologies, as earlier discussed herein, are of substantial concern to ARRL. Amateur equipment (with the exception of commercially manufactured receivers at VHF and above, scanning receivers, and certain linear amplifiers) has never been subject to Commission authorization requirements. Traditionally, and to the present, the Amateur Radio Service has been exempted from these requirements, applicable to most other radio services.

¹² See, 47 C.F.R. § 2.815 and 47 C.F.R. § 97.315

This is because amateur equipment has been either designed and built by amateurs themselves, or commercially manufactured but (intentionally) subject to modifications, improvements, refinements and adaptations made by the licensees which would otherwise void an equipment authorization grant by the Commission. As noted above, the Amateur Radio Service is essentially an experimental service, in which equipment, even if commercially manufactured, is incorporated into station architecture in different ways and improved upon by the licensees themselves. Amateur Radio is unique in this respect among the services administered by the Commission. It is necessary to preserve and protect this flexibility, because to do otherwise would serve as a disincentive to experiment and a disincentive to conduct the technical self-training that is a hallmark of the Amateur Radio Service. It would make commercially manufactured amateur equipment more expensive and less useful to the licensees, because it could not be substantially modified or adapted for incorporation in other station architecture.

22. Against this background of Commission forbearance relative to regulation of amateur equipment, the advent of cognitive radio technology raises issues as to the necessity of software registration, FCC authorization of the software, and security issues. It is the position of ARRL that cognitive radio technology software should presently be subject only to current Part 2 equipment authorization requirements and that separate equipment authorization regulations are unnecessary. The present equipment authorization requirements would be applicable to non-amateur SDRs, cognitive radios, and presumably to the hardware/software combination that would comprise an SDR or cognitive radio system. It is expected that those systems would be tested in the configuration and power levels that would constitute the “worst case” relative to specific

absorption rate (SAR) and maximum permitted exposure (MPE) levels, out-of-allocated-band emissions, and the typical measurements applicable to grants of certification for intentional radiator devices and transmitters in services other than the Amateur Radio Service. It would appear to ARRL that the present measurements required by Part 2 of the Commission's rules would be sufficient to address the combination of hardware and software incorporated in non-amateur CRT devices. The Commission has recently adopted regulations for Technical Certification Bodies (TCBs) to perform testing and certification of RF equipment. There would appear no need at present to modify these procedures to accommodate the advent of non-amateur cognitive radio technologies.

23. It is understood that the software for cognitive radios could be modified and reprogrammed quickly. The Commission's rules presently regulate what constitutes permissive changes to certificated equipment and what does not, and the present definitions would appear adequate to address post-authorization software changes. It would not seem necessary to regulate the companies that change software, or the means by which software can be downloaded. The software would be used to determine the frequency bands and frequencies on which the cognitive radios can operate. Therefore, there is an increased risk that software could be marketed which would cause a cognitive radio to operate in such a manner as to create interference or operate on bands that are allocated to services other than for which the cognitive radio was authorized in the first place. While licensees which utilize the cognitive radio can be held accountable for such instances, that is not the most expeditious means of conducting enforcement. The manufacturers and purveyors of aftermarket software upgrades and modifications for cognitive radios should be required to require proof of licensing prior to providing

software which would permit out-of-allocated-band operation or interference caused directly by the use of software or software upgrades purchased or distributed from those sources.

24. Frequency blocking would appear to be facilitated by the use of cognitive radio technologies, and Commission rules could limit the configuration of software intended for certain services so as to preclude the use of cognitive radios in bands outside of those allocated for the intended service. ARRL suggests that, by rule, software intended for services other than the Amateur Radio Service should be configured so as to block amateur allocations. As to privacy considerations, this is not a problem in the Amateur Radio Service, as all amateur communications are subject to monitoring. Anti-tampering or other security requirements are antithetical to the Amateur Radio Service, because they significantly inhibit experimentation with software and hardware. No such restrictions should be applicable to cognitive radio technologies for amateur use. Authentication codes to be displayed on LCD displays in the hardware may have some justification in other services, but software experimentation in the Amateur Radio Service would be inhibited by such a requirement, and it would appear unnecessary in the Amateur Radio Service.

VII. Conclusions

25. ARRL is opposed to any proposal that would permit Part 15 devices to operate at increased transmitter power levels in the Amateur allocations. ARRL opposes increases of power levels for undefined and undefinable “rural areas” because the practical radio horizon at higher Part 15 power levels makes interference with the Amateur and Amateur-Satellite service operations in many frequency bands inevitable.

CRT technology does not create an opportunity to increase the power level of Part 15 devices, which is already so substantial as to make a mockery of the statutory licensing requirement of Section 301 of the Communications Act of 1934.

26. The Amateur Radio Service is a fertile testing and development ground for SDRs and cognitive radio technologies, which are the subjects of current experimentation and development of hardware and software. The flexible regulations, shared frequency allocations, and the multiplicity of transmission modes in common use in the Amateur Radio Service constitute the proper environment for the development and deployment of equipment using SDR and cognitive radio technologies. In particular, such technology would be especially useful in amateur radio disaster relief and emergency communications. In the future, interoperability between and among amateur stations and public safety agencies and other agencies served traditionally by radio amateurs will be enhanced by CRT technology. These technologies will allow ever greater participation by amateurs in restoration of communications systems following a wide-area emergency or disaster, and in conducting disaster relief efforts on-site in coordination with served agencies.

27. While cognitive radio technologies are likely to enhance spectrum efficiency, regulatory changes at the outset should be relative to the frequency assignment process and those necessary to permit different, flexible transmission modes, so as to accommodate dynamic frequency and bandwidth selection. There are no allocation changes necessary in the future in order to implement cognitive radio technologies in given radio services. It is important in the Amateur Radio Service to avoid creating regulatory obstacles antithetical to experimentation and flexibility in conducting amateur

operations. Therefore, equipment authorization requirements should not be imposed on cognitive radio technology hardware or software for use in amateur communications on amateur bands.

28. Enforcement of existing Part 97 rules, and the current level of regulatory compliance in the Amateur Service is quite adequate for the foreseeable future. Cognitive and software defined radios should and can be regulated within the existing rules. ARRL anticipates that the current protections available in the various Service rules will be sufficient to protect the Amateur Service from interference that may be generated by non-amateur cognitive radios.

29. ARRL supports the Commission's efforts to encourage and promote Amateur Radio experimentation with cognitive radio technologies, including designing advanced DACs for amateur applications.

Therefore, the foregoing considered, ARRL, the National Association for

Amateur Radio, respectfully requests that the Commission enact rules for cognitive radio technology in accordance with the foregoing comments, and not otherwise.

Respectfully submitted,

**ARRL, THE NATIONAL ASSOCIATION FOR
AMATEUR RADIO**

225 Main Street
Newington, CT 06111-1494

By: _____
Christopher D. Imlay
Its General Counsel

BOOTH, FRERET, IMLAY & TEPPER, P.C.
14356 Cape May Road
Silver Spring, MD 20904-6011
(301) 384-5525

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